Radiation Monitoring:
Whole Body Counting

Dave Lochbaum

December 2021

What is Whole Body Counting?

There are different whole body counter designs, such as this chair-type.

Whole body counters use sensitive instruments to detect gamma rays emitted from radioactive materials inside the body.

The materials could have been inhaled or ingested.

Counting takes a few minutes.

Image Source: Lawrence Livermore National Laboratory, "Individual radiation Protection Monitoring in the Marshall Islands: Utrōk Atoll (2010-2012)," LLLNL-TR-665509, Livermore, CA, November 2014.

Text Source: Los Alamos National Laboratory, "Radiological Worker II Training, Course 20301 (Live), Course 12909 (Test)," LA-UR-17-20254, Los Alamos, NM, January 13, 2017.

Why Do Whole Body Counting?

"A Whole Body Counter is an instrument which is used to detect radioactive materials within your body. This radioactivity is not easily measured by other monitoring devices.

How often you receive a Whole Body Count depends, on your job and the materials you work with. Some people are counted about every three months. Others may be counted every year.

Many radionuclides will give off several gamma rays of different energies and thus will show several peaks, sometimes of different heights. By looking at the position and height of these peaks, the Whole Body Counter Specialist can identify the radionuclides in your body and estimate the amount of them present."

Source: Oak Ridge National Laboratory, "The ORNL Whole Body Counter," ORNL/M-454, Oak Ridge, TN, December 1988.

"One of the least invasive techniques for measuring radioisotopes in the body is the so-called whole-body counter. It began around problems of bone seekers, with the methods developed for determining the radium burden of dial painters and patients. The methods of the 1930s were sensitive only to about 0.1 to 0.2 µg radium equivalent. The Los Alamos 4-n liquid scintillation counter was sensitive to about 0.0001 µg of radium equivalent or 1% of the total body ^{40}K. The sodium iodide crystal counter at ANL was sensitive to about 0.0003 µg radium equivalent. Naturally, such sensitivity led to many uses beyond determination of radium equivalents. Among these was a considerable amount of investigation into the metabolism of body potassium in adults and children, the changes with age, determination of body muscle mass, etc., in health and disease."

Source: Stannard, J. Newell, Professor Emeritus, School of Medicine and Dosimetry, University of Rochester, "Radioactivity and Health: A History," DOE/RL/01830-T59, Richland, WA, October 1988.

Whole Body Counting Precedents

Oak Ridge National Lab (TN)

"Whole Body Counters, also known as total-body counters, in-vivo gamma spectrometers, etc., play an integral part in general health physics and radiation safety programs. The ORNL facility, known as the ORNL Whole Body Counter, has been in operation since May 1961.

The general purpose of the ORNL Whole Body Counter Is to provide a rapid estimation of the type and quantity of radionuclide deposited In the human body. Greater than 90% accuracy in estimating internal deposition can be achieved depending upon the energy of the photons or X rays being detected."

Source: Oak Ridge National Laboratory, "The Oak Ridge National Laboratory Whole-Body Counter: Internal Operating Procedure Manual," ORNL/TM-8423, Oak Ridge, TN, August 1982.

Nevada Test Site (NV)

"The Off-Site Human Surveillance Program was initiated in December 1970 to determine levels of radioactive nuclides in some of the families residing in communities and ranches surrounding the Nevada Test Site. Biannual counting is performed in the spring and fall. This program started with 34 families (142 individuals). In 1985, 16 of these families (37 individuals) were still active in the program together with 18 families added in recent years.

These persons travel to the Environmental Monitoring Systems Laboratory where a whole-body count of each person is made to determine the body burden of gamma-emitting radionuclides."

Source: U.S. Environmental Protection Agency, "Off-Site Environmental Monitoring Report: Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1985," EPA/600/4-86/022, DOE/DP/00539/056, Las Vegas, NV, April 1986.

Nevada Test Site (NV) (continued)

Source: U.S. Environmental Protection Agency, "Off-Site Environmental Monitoring Report: Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1985," EPA/600/4-86/022, DOE/DP/00539/056, Las Vegas, NV, April 1986.

Nevada Test Site (NV) (continued)

"In 1985, [whole body] counts were made on 106 off-site residents, as well as on 260 other individuals for occupational or other reasons. Natural potassium-40 was found as expected, but no nuclear test related radioactivity was detected.

The Radiological Safety Program portion requires all employees who may be exposed to radioactive materials in the course of their work to undergo a periodic whole-body count."

Source: U.S. Environmental Protection Agency, "Off-Site Environmental Monitoring Report: Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1985," EPA/600/4-86/022, DOE/DP/00539/056, Las Vegas, NV, April 1986.

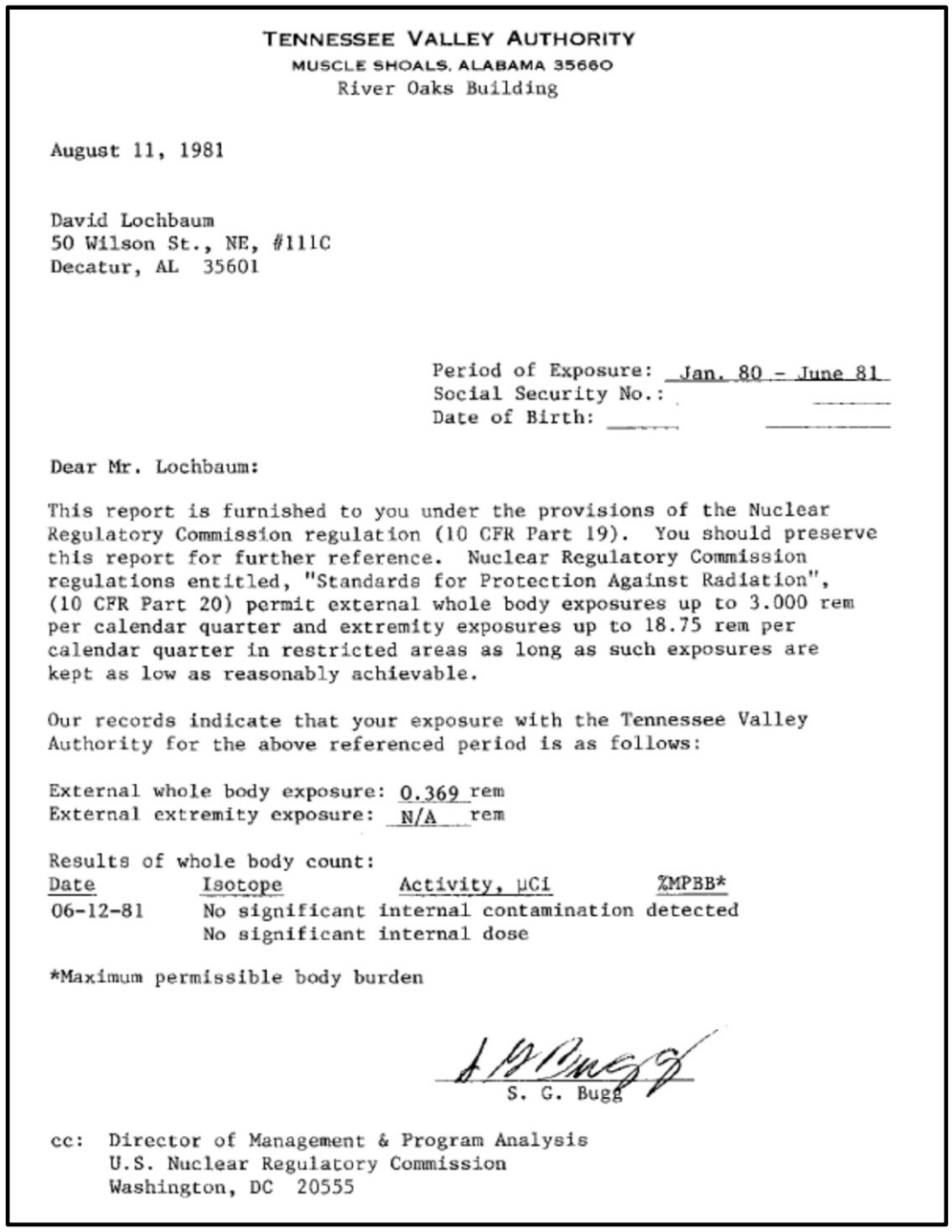
Nuclear Test Site Areas (US)

"During 1991, a total of 2,800 gamma spectra were obtained from whole-body counting of 350 persons (including those individuals who were counted twice). One hundred and six of the counts were on participants of the Offsite Internal Dosimetry Program. ... No internal exposure above applicable regulatory limits was detected in either occupationally exposed individuals or members of the general public who participated in the Internal Dosimetry Program at EMSLLV.

Some members of the general public request whole body counts because they are concerned about possible radiation exposure."

Source: U.S. Environmental Protection Agency, "Offsite Environmental Monitoring Report: Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1991," EPA 600/R-93/141, Las Vegas, NV, January 1992.

Dave Lochbaum (AL)



TENNESSEE VALLEY AUTHORITY
MUSCLE SHOALS, ALABAMA 35660
River Oaks Building

August 11, 1981

David Lochbaum
50 Wilson St., NE, #111C
Decatur, AL 35601

Period of Exposure: Jan. 80 - June 81
Social Security No.:
Date of Birth:

Dear Mr. Lochbaum:

This report is furnished to you under the provisions of the Nuclear Regulatory Commission regulation (10 CFR Part 19). You should preserve this report for further reference. Nuclear Regulatory Commission regulations entitled, "Standards for Protection Against Radiation", (10 CFR Part 20) permit external whole body exposures up to 3.000 rem per calendar quarter and extremity exposures up to 18.75 rem per calendar quarter in restricted areas as long as such exposures are kept as low as reasonably achievable.

Our records indicate that your exposure with the Tennessee Valley Authority for the above referenced period is as follows:

External whole body exposure: 0.369 rem
External extremity exposure: N/A rem

Results of whole body count:

Date	Isotope	Activity, µCi	%MPBB*
06-12-81	No significant internal contamination detected		
	No significant internal dose		

*Maximum permissible body burden

S. G. Bugg

cc: Director of Management & Program Analysis
U.S. Nuclear Regulatory Commission
Washington, DC 20555

While working at the Browns Ferry Nuclear Plant, I had neither received an unplanned exposure to radiation nor was suspected of having inhaled or ingested radioactive materials.

Nevertheless, like my co-workers, I received a whole body count to verify my radiation exposure complied with federal requirements.

Pennsylvania (PA)

"The need for monitoring and evaluating the health status of populations was clearly indicated by the accident at Three Mile Island on March 28. 1979. Had the accident been more serious in a health threatening sense, the informational needs of involved government agencies and a concerned public could not have been adequately served in a timely manner.

[The objectives of the Epidemiologic Surveillance System includes to] Monitor and evaluate the health indices in vicinity of nuclear facilities on a regular basis to detect any significant changes over time or differences from norms that may have occurred or been observed."

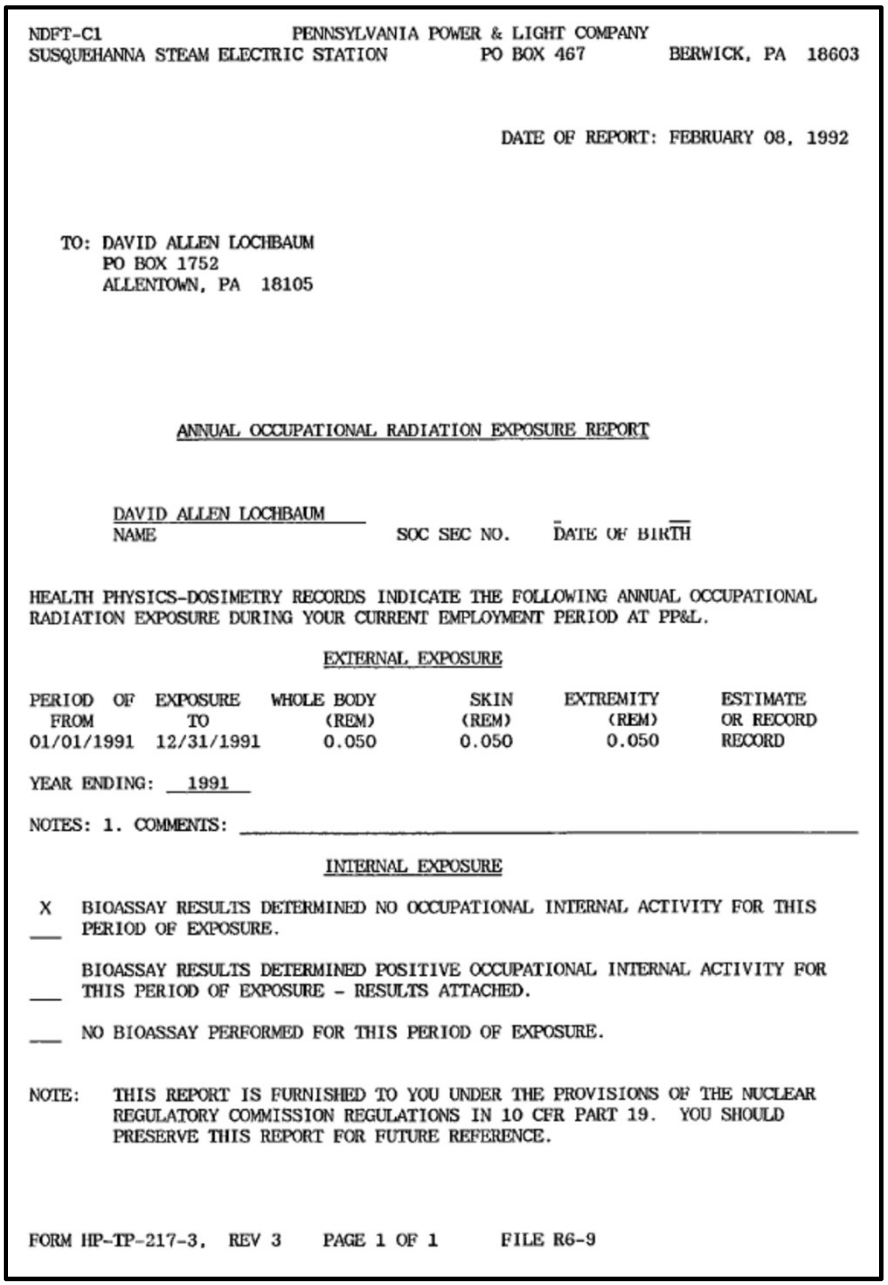
Source: Pennsylvania Department of Health, "Epidemiologic Surveillance in Pennsylvania: A Case of Nuclear Power Plants," Harrisburg, PA, June 1984. (ML20127F252)

West Valley Facility (NY)

"Individuals undergo a whole-body count upon being hired and at the time the employment is ended."

Source: West Valley Nuclear Services Co., Inc., "Lessons Learned At West Valley During Facility Decontamination for Re-Use," DOE/NE/44139-54, West Valley, NY, November 1988.

Dave Lochbaum (PA)



NDFT-C1 PENNSYLVANIA POWER & LIGHT COMPANY
SUSQUEHANNA STEAM ELECTRIC STATION PO BOX 467 BERWICK, PA 18603

DATE OF REPORT: FEBRUARY 08, 1992

TO: DAVID ALLEN LOCHBAUM
PO BOX 1752
ALLENTOWN, PA 18105

ANNUAL OCCUPATIONAL RADIATION EXPOSURE REPORT

DAVID ALLEN LOCHBAUM — NAME — SOC SEC NO. — DATE OF BIRTH

HEALTH PHYSICS-DOSIMETRY RECORDS INDICATE THE FOLLOWING ANNUAL OCCUPATIONAL RADIATION EXPOSURE DURING YOUR CURRENT EMPLOYMENT PERIOD AT PP&L.

EXTERNAL EXPOSURE

PERIOD OF EXPOSURE FROM	TO	WHOLE BODY (REM)	SKIN (REM)	EXTREMITY (REM)	ESTIMATE OR RECORD
01/01/1991	12/31/1991	0.050	0.050	0.050	RECORD

YEAR ENDING: 1991

NOTES: 1. COMMENTS: _____

INTERNAL EXPOSURE

X BIOASSAY RESULTS DETERMINED NO OCCUPATIONAL INTERNAL ACTIVITY FOR THIS PERIOD OF EXPOSURE.

___ BIOASSAY RESULTS DETERMINED POSITIVE OCCUPATIONAL INTERNAL ACTIVITY FOR THIS PERIOD OF EXPOSURE - RESULTS ATTACHED.

___ NO BIOASSAY PERFORMED FOR THIS PERIOD OF EXPOSURE.

NOTE: THIS REPORT IS FURNISHED TO YOU UNDER THE PROVISIONS OF THE NUCLEAR REGULATORY COMMISSION REGULATIONS IN 10 CFR PART 19. YOU SHOULD PRESERVE THIS REPORT FOR FUTURE REFERENCE.

FORM HP-TP-217-3, REV 3 PAGE 1 OF 1 FILE R6-9

While working at the Susquehanna nuclear plant, I had neither received an unplanned exposure to radiation nor was suspected of having inhaled or ingested radioactive materials.

Nevertheless, like my co-workers, I received a whole body count to verify my entire radiation exposure complied with federal requirements.

Savannah River Site (GA)

"The U.S._Department of Energy (DOE) proposes to construct and operate a new *in-vivo* counting facility at the Savannah River Site (SRS), near Aiken, South Carolina for the monitoring of employees for internal radionuclides. The proposed facility, titled the new Whole Body Counter (WBC) facility, would house both the existing and additional new *in-vivo* counting equipment and facility support operations.

The SRS is striving to have all 8900 workers, of which approximately 6600 work the day shift, receive chest counts on an annual basis to serve as back-up for the bioassay program."

Source: U.S. Department of Energy, "Environmental Assessment for the New Whole Body Counter Facility at the Savannah River Site," DOE/EA-0801, Savannah River Site, GA, January 1993.

Marshall Islands

"In 1998, the United States Department of Energy (U.S. DOE) began a series of initiatives to address the long-term radiological surveillance needs of resettling populations exposed to elevated levels of residual fallout at the former U.S. nuclear test sites within the Marshall Islands. With support from the local atoll governments, three whole-body counting facilities were established on Enewetak, Rongelap, and Majuro Atolls, and tasked with monitoring the health and safety of the populations living there."

Source: Lawrence Livermore National Laboratory, "Performance Evaluation of Whole-Body Counting Facilities in the Marshall Island (2014-2017)," LLLNL-TR-766784, Livermore, CA, November 2018.

Marshall Islands (continued)

"The main pathway for exposure to residual fallout contamination in the northern Marshall Islands is through ingestion of cesium-137 contained in locally grown foods such as coconut, *Pandanus* fruit and breadfruit .... The strategic objective of the Marshall Islands Whole Body Counting Program is to offer island residents an unprecedented level of radiation protection monitoring until such time that it is clearly demonstrated that radiation surveillance measures can be relaxed. The value of whole body count radiation protection monitoring resides in the fact that the data provides a direct measure of radionuclide uptake by local populations."

Source: Lawrence Livermore National Laboratory, "Individual Radiation Protection Monitoring in the Marshall Islands: Utrōk Atoll (2010-2012)," LLLNL-TR-665509, Livermore, CA, November 2014.

Risk From Low Radiation Doses

"The report of the Committee on the Biological Effects of Ionizing Radiation … states that

> … departure from linearity cannot be excluded at low doses below the range of observation. Such departures could be in the direction of either an increased or decreased risk. Moreover, epidemiologic data cannot rigorously exclude the existence of a threshold in the 100 mrem dose range. Thus, the possibility that there may be no risk from exposures comparable to external natural background radiation cannot be ruled out. At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero."

Source: U.S. Nuclear Regulatory Commission, "Instruction Concerning Risks from Occupatonal Radiation Exposure," Regulatory Guide 8.29, Rev. 1, Washington, DC, February 1996. (ML003739438)

"The issue of beneficial effects from low doses, or hormesis, in cellular systems is addressed by the United Nations Scientific Committee on the Effects of Atomic Radiation. UNSCEAR states that "... it would be premature to conclude that cellular adaptive responses could convey possible beneficial effects to the organism that would outweigh the detrimental effects of exposures to low doses of low-LET radiation.

What are the estimates of the risk of fatal cancer from radiation exposure?

We don't know exactly what the chances are of getting cancer from a low-level radiation dose."

Source: U.S. Nuclear Regulatory Commission, "Instruction Concerning Risks from Occupatonal Radiation Exposure," Regulatory Guide 8.29, Rev. 1, Washington, DC, February 1996. (ML003739438)

Public Whole Bodies Count, Too

DOSE LIMIT
5 rem/yr

Federal regulations establish an annual limit on the permissible radiation exposure to adult nuclear workers.

DOSE LIMIT
0.1 rem/yr

Federal regulations establish an annual limit on the permissible radiation exposure to members of the public.

DOSE LIMIT
5 rem/yr

- **Marked and locked radiation areas**
- **Individual dosimeters**
- **Film badges**
- **Whole body counts**

Federal regulations establish an annual limit on the permissible radiation exposure to adult nuclear workers.

The worker limits are backed by measures intended to verify the dose limits are not violated.

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DOSE LIMIT
0.1 rem/yr

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Federal regulations establish an annual limit on the permissible radiation exposure to members of the public.

The public limits lack comparable measures to verify compliance.

Unlike Marshall Islanders, civilians living near nuclear test sites, and nuclear workers at DOE and NRC licensed facilities, civilians living near NRC licensing nuclear power plants do not receive periodic whole body counts to verify their radiation exposures are within permissible federal limits.

The NRC requires owners to submit data on nuclear worker radiation doses to inform its decisions on research and regulatory efforts.

Whole body counting of civilians around Indian Point and other operating/decommissioning nuclear plants would either confirm currently unverified assumptions about public health or identify gaps warranting closure.

The NRC requires occupational radiation monitoring data to be submitted for the following purposes:

1. **"The data permit the evaluation of trends, both favorable and unfavorable, from the viewpoint of the effectiveness of overall NRC/licensee radiation protection and as low as is reasonably achievable (ALARA) efforts by licensees."**

Lack of public radiation monitoring data prevents evaluation of trends and assessment of the effectiveness of overall radiation protection efforts.

2. **"The data assist in the evaluation of the radiological risk associated with certain categories of NRC-licensed activities and are used for comparative analyses of radiation protection performance (e.g., U.S./foreign, boiling-water reactors/pressurized-water reactors [BWRs/PWRs], civilian/military, facility/facility, nuclear industry/other industries)."**

Comparative analyses of non-existent data are simple, but simply useless.

Source: U.S. Nuclear Regulatory Commission, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities 2018, "NUREEG-0713, Vol. 40, Washington, DC, March 2020. (ML20087J424)

Source: Dave Lochbaum

The NRC requires occupational radiation monitoring data to be submitted for the following purposes:

3. "The data are used within the NRC Reactor Oversight Process for inspection planning and in the Significance Determination Process."

Non-existent public radiation monitoring data cannot be used to plan NRC inspections during nuclear plant decommissioning.

4. "The data permit an evaluation of radiation exposure to transient individuals."

Non-existent public radiation monitoring data cannot be used to evaluate radiation exposure to members of the public.

5. "The data are used to establish priorities for the use of NRC health physics resources: research, standards development, regulatory program development, and inspections conducted at NRC-licensed facilities."

Non-existent public radiation monitoring data has zero value in establishing NRC's priorities for research and inspections.

Source: U.S. Nuclear Regulatory Commission, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities 2018, "NUREEG-0713, Vol. 40, Washington, DC, March 2020. (ML20087J424)

Source: Dave Lochbaum

The NRC requires occupational radiation monitoring data to be submitted for the following purposes:

6. "The data provide facts for answering Congressional and administration inquiries and for responding to questions raised by the public."

Non-existent public radiation monitoring data deprives NRC of facts when answering Congressional inquires about radiation exposure to members of the public.

7. "The data are used to provide radiation exposure histories to individuals who were exposed to radiation at NRC-licensed facilities."

Non-existent public radiation monitoring data means members of the public have no history of exposure to radioactive materials released from NRC-licensed facilities.

8. "The data provide information that may be used to conduct epidemiologic studies."

Non-existent public radiation monitoring data reduces uncertainties in epidemiological studies (e.g., they are CERTAIN that individual exposure data is not available.)

Source: U.S. Nuclear Regulatory Commission, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities 2018, "NUREEG-0713, Vol. 40, Washington, DC, March 2020. (ML20087J424)

Source: Dave Lochbaum